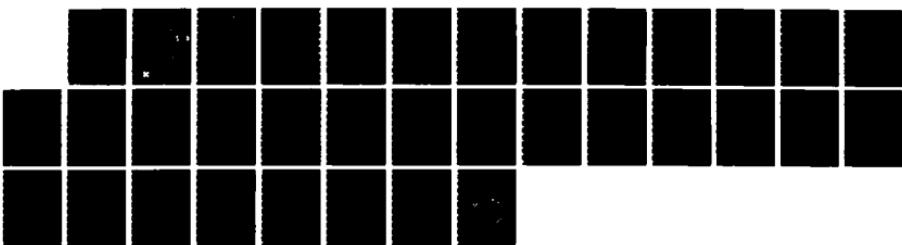
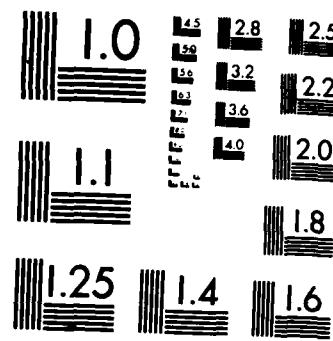


AD-A173 876 TECHNICAL REVIEW AND ANALYSIS OF HARDWARE VERSUS  
MANPOWER COMPARABILITY A (U) ARMY MATERIEL READINESS  
SUPPORT ACTIVITY LEXINGTON KY J V SMITH 01 MAY 86  
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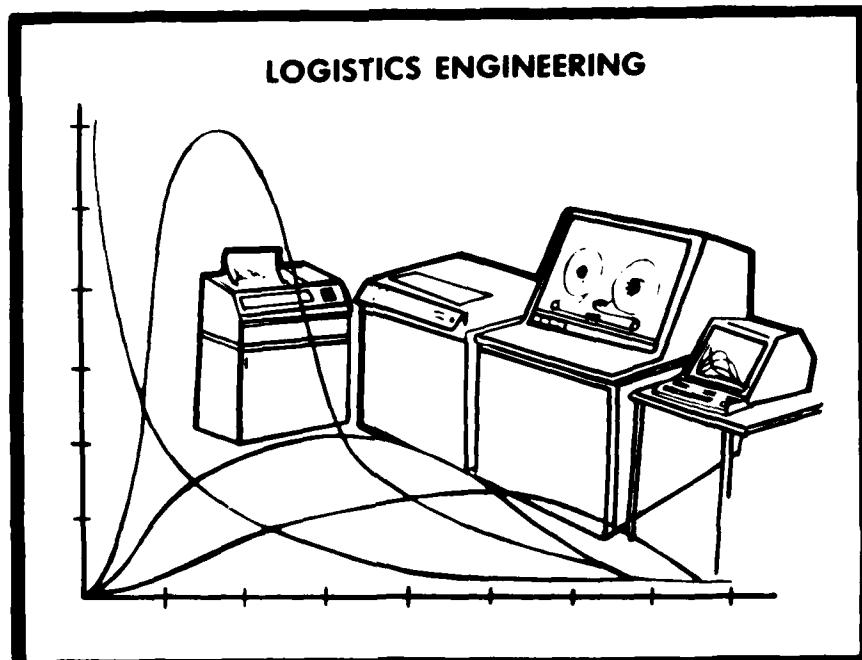
## LOGISTICS SUPPORT ANALYSIS TECHNIQUES INFORMATION

AD-A173 876

**TECHNICAL REVIEW AND ANALYSIS  
OF  
HARDware vs MANpower  
COMPARABILITY ANALYSIS METHODOLOGY**

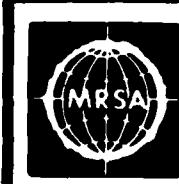
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US ARMY MATERIEL COMMAND  
MATERIEL READINESS SUPPORT ACTIVITY  
LEXINGTON, KENTUCKY 40511-5101

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The MRSA analysis team for this TRA consisted of the following personnel: Mr. John Peer, MRSA LSAT coordinator; Mr. Leslie Adkins, Chief, Engineering Analysis Section; Mr. John V. Smith, team chief; Mr. Greg Tarver, advisory assistant; and Ms. Betty Clarke, clerk-typist.

The MRSA team would like to especially thank the following personnel for their efforts/assistance: Soldier Support Center-National Capital Region (SSC-NCR), Army Research Institute (ARI), and Dynamic Research Corporation (DRC).

## DISCLAIMER

This TRA was conducted by USAMC MRSA to provide an independent evaluation of Hardware vs Manpower (HARDMAN) Comparability Analysis Methodology. The contents of this report represent the views, conclusions and recommendations of the Commander, MRSA, and do not necessarily reflect the official views of the Department of the Army or HQ AMC. MRSA is prepared to discuss all issues and findings of this TRA at the discretion of HQ AMC or the requesting agency/activity.

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TABLE OF CONTENTS

	<u>Page</u>
SECTION I. <u>EXECUTIVE SUMMARY.</u>	1-1
SECTION II. <u>TECHNICAL REVIEW AND ANALYSIS (TRA).</u>	
A. PURPOSE.	2-1
B. EVALUATION METHODOLOGY.	2-1
C. COORDINATION.	2-1
D. TECHNIQUE DESCRIPTION.	2-1
E. BACKGROUND.	2-7
SECTION III. <u>TECHNICAL EVALUATION.</u>	
A. APPLICABILITY TO MIL-STD-1388-1A.	3-1
B. CALCULATIONS/EQUATIONS.	3-7
C. DOCUMENTATION.	3-7
D. INPUT REQUIREMENTS.	3-7
E. OUTPUT REQUIREMENTS.	3-8
F. STRENGTHS AND LIMITATIONS.	3-9
G. CONCLUSIONS/RECOMMENDATIONS.	3-9
APPENDICES.	
A. INPUT PARAMETERS.	A-1
B. DATA SOURCES.	B-1
C. EQUATIONS.	C-1
D. ACRONYMS.	D-1
E. DISTRIBUTION LIST.	E-1

## **SECTION I. EXECUTIVE SUMMARY.**

### **A. INTRODUCTION.**

This TRA was conducted to evaluate the potential use of HARDMAN Comparability Analysis Methodology (HCM) in satisfying the Logistic Support Analysis (LSA) tasks set forth in MIL-STD-1388-1A. This report is the result of an in-depth review of the HCM documentation in accordance with the methodology identified in paragraph B, Section II. The report will center on the ability of the model to fulfill the features stated in the documentation and the model's applicability to MIL-STD-1388-1A tasks. Proposals for modification or inquiries with respect to application of the HCM should be addressed to the Commander, USAMC, Materiel Readiness Support Activity, ATTN: AMXMD-EL, Lexington, KY 40511-5101. Telephone inquiries should be addressed to Mr. John V. Smith, AUTOVON 745-3986, or commercial (606) 293-3986.

### **B. COORDINATION.**

The final report for HCM TRA will be coordinated with SSC-NCR and ARI. Differences of opinion, if any, will be discussed in the Technical Evaluation and summarized in the conclusions paragraph G, section III. Initial findings were presented to the LSA Technical Working Group (LSA-TWG) during the 4th Qtr FY 85 meeting.

### **C. BACKGROUND.**

The HCM was developed under contract with the Navy HARDMAN Office (OP-112C), to assist in assessment of manpower, personnel, and training (MPT) requirements early in the weapon system acquisition process. It has since been adapted for the Army's needs under the supervision of SSC-NCR and ARI. SSC-NCR has contracted with DRC, Boston, MA to enhance the methodology and to conduct HCM analyses on selected Army systems. The Army proponent for HARDMAN is SSC-NCR in Alexandria, VA.

### **D. SUMMARY OF FINDINGS.**

1. The HCM is applicable to the following MIL-STD-1388-1A tasks: 201, Use Study; 203, Comparative Analysis; 204, Technological Opportunities; 205, Supportability and Supportability Related Design Factors; 301, Functional Requirements Identification; 302, Support System Alternatives; 303, Evaluation of Alternatives and Tradeoff Analysis; and, 401, Task Analysis.

NOTE: Although HCM does not completely satisfy all the tasks listed above, it can be useful in performing these tasks. A more detailed description of task applicability is provided in Section III.

2. The HCM Guide was compiled jointly under the authority of ARI and SSC-NCR. The guide, Research Product 85-19, Apr 85 consists of five volumes which constitute a detailed specification of the Army HCM as applied to major materiel systems. The basic analytic approach is comparability analysis, a process which uses data from similar existing systems and projects the MPT requirements of the proposed system.

While most HCM analyses have been performed manually, there is increasing interest in automating the procedures using the Man Integrated Systems Technology (MIST) Program. Use of MIST eliminates manual inputs of numerous worksheets by allowing data entry via computer terminal. As a consequence, calculations are much quicker and more accurate, changes can be made more quickly, and report documentation requires no additional typing since properly formatted computer printouts will be available. MIST is particularly advantageous when there are numerous changes to the system being analyzed or when multiple tradeoff analyses need to be performed. More information on MIST is available from ARI, Manned Systems Group, AV 284-8943 or Commercial (202) 274-8943.

3. HCM interfaces with the LSA records by providing data to the following LSAR data records.

A--Operation and Maintenance Requirements--HCM conducted early in pre-concept and concept phases can provide government developed operational and maintenance requirements data for the A record.

C--Operation and Maintenance Task Summary--HCM identifies initial operational and maintenance tasks.

D1--Personnel and Support Requirements--HCM calculates the personnel needed to support the workload requirement of a proposed system.

E1--Support Equipment and Training Materiel Description and Justification--HCM identifies training devices along with the special training requirements necessary to operate and support the proposed system.

G--Skill Evaluation and Justification--HCM identifies all MOS/skill levels, with necessary training requirements, to support the proposed system.

4. The documentation for HCM procedures is well written and contains numerous charts which illustrate the logical flow of the analysis and data. There are isolated cases of numbers

in equations that have not been substantiated within the guide, but can be verified with little effort by the analyst.

5. The equations used in the HCM were found to be in accordance with all regulations governing MPT.

6. HCM is very data intensive. Accuracy and credibility of the results depends heavily on the quantity, quality and accuracy of the data needed to apply the methodology.

7. Assumptions and constraints are associated with each major HCM step and many substeps. Therefore, these assumptions and constraints should be considered when HCM results are being reviewed.

8. The HCM focuses only on MPT costs when performing trade-off analysis and not complete life cycle costs considerations.

9. HCM is very labor intensive. It is estimated to require eight people with varying skills and experience levels to perform a HCM analysis in a nominal timeframe of 7.5 months.

#### E. AVAILABILITY.

The latest approved addition of the HCM Guide is available through the Defense Technical Information Center (DTIC), Cameron Station, Alexandria, VA 22304-6145. The HCM Guide, Research Product 85-19, Apr 85, has five volumes including the Manager's Guide, System Analysis, Requirements Analysis, Interpretation and Evaluation and Analysis Support Information.

#### F. CONCLUSIONS.

1. The HCM is applicable to the LSA tasks stated in paragraph A, Section III. MRSA recommends the use of HCM as a tool in performing these tasks. However, it should be noted that HCM application considers MPT requirements only.

2. ARI has developed a software package designed to support execution of HCM. The software is called Man Integrated Systems Technology (MIST). Both the HCM Guide and the MIST Guide are available to give qualified analysts the guidance necessary to perform HCM analysis. Current HCM applications are contracted out by SSC-NCR to DRC in Andover, MA.

3. HCM applications are more cost effective in early life cycle phases (i.e., Pre-concept\*, Concept and early in Demonstration/Validation), providing the decision makers with beneficial human resource requirements and costs associated with emerging system design. This information provides an early targeting of problem areas in system supportability and permits effective tradeoff analyses to be conducted before system design becomes mature.

\* When applicable.

4. HCM depends heavily on the quantity and quality of data available for conducting the analysis. The results of HCM will only be as reliable as the data utilized for input into the methodology. A quality control check on data to be used as input should be made prior to analysis to assure an accurate HCM product.

## **SECTION II. TECHNICAL REVIEW AND ANALYSIS (TRA).**

### **A. PURPOSE.**

A TRA is conducted to assess the ability of LSA techniques to satisfy the LSA tasks set forth in MIL-STD-1388-1A, 11 Apr 83 Logistic Support Analysis. The objectives of the analysis are: (1) to determine if the calculations used in the technique conform to regulations which govern MPT; (2) to establish expertise within MRSA on the functional use of the model; and, (3) to determine resources required to utilize the technique and the potential areas of application. The TRA considers all aspects of LSA techniques, including user training availability, computer resources requirements, documentation availability, conformation with regulatory guidance, applicability to various commodities, automatic data processing requirements and validity of input requirements and output reports.

### **B. EVALUATION METHODOLOGY.**

The analysis was accomplished by first analyzing the requirements of each of the tasks described in MIL-STD-1388-1A to determine if the technique could be applied to any of the LSA tasks. Each of the subtasks which make up an applicable task were then analyzed to determine to what extent the model could satisfy the requirements of the task. Attention was also given to the output uses and to which phase(s) of the life cycle it could be applied. Calculations and defined equations were compared with regulatory requirements which govern MPT. All available documentation was gathered and surveyed for accuracy, completeness and ease of application.

### **C. COORDINATION.**

The final report of HCM will be coordinated with SSC-NCR and ARI. Differences of opinion, if any, will be discussed in the Technical Evaluation and summarized in the conclusions, Section III of this report. Findings will be presented to the LSA-TWG during 86.

### **D. TECHNIQUE DESCRIPTION.**

The HCM is a structured approach using analytical tools to determine MPT requirements for a weapon system during the early phases of the materiel acquisition process. It provides documented assessments of human resource requirements and costs associated with emerging system design.

These MPT requirements projected by HCM give information used for support of decisions related to research, development and acquisition issues and to determine the impact of a system's MPT resource demands on the Army's present and/or projected supply of those resources. The result is a methodology that can give an early determination of problem areas in system supportability. Effective tradeoff analyses can then be conducted through iterations of the methodology.

HCM uses knowledge about similar existing systems to project the workload and associated manpower, personnel pipeline, and institutional training requirements for a proposed system. HCM is composed of six major inter-related steps: (1) System Analysis; (2) Manpower Analysis; (3) Training Resource Requirements Analysis; (4) Personnel Analysis; (5) Impact Analysis; and, (6) Tradeoff Analysis. These steps are broken down into more detailed substeps. Each substep provides specific outputs necessary to perform other substeps within the HCM.

The system analysis step of HCM has four basic objectives. The first is to determine the functions and functional requirements the system is required to perform on the battlefield. HCM identifies the functions; examines these functions against the battlefield conditions and desired performance; and, allocates the functional requirements to equipment, people or information categories. The inputs to this subgroup include the Battlefield Development Plan (BDP), Mission Area Analysis (MAA), Operational and Organizational Plan (O&O Plan) and System Requirements Documents such as Justification for Major System New Start (JMSNS) and Required Operational Capability (ROC).

The second objective of system analysis is to identify and determine the equipment configurations that meet the qualifications for the predecessor, baseline comparison and proposed systems. The Predecessor System, as defined by HCM, is the system or subsystem currently in the Army inventory, that can no longer satisfy the desired functional requirements of the new mission or threat and has been identified to be replaced. The MAA usually identifies the system to be replaced. The replacement is usually advocated in the event of: excessive operation and/or support costs associated with the present system, a perceived enemy threat which cannot be met with existing equipment, and/or technological advances identified through Research and Development. The existence

of a Predecessor System simplifies the System Analysis step by establishing the initial operational and organizational context for the new system. The HCM analyst also uses the Predecessor System equipment in developing the Baseline Comparison System (BCS). The degree to which Predecessor System components are incorporated into the BCS depends on whether the developmental system represents a Predecessor upgrade or a totally new system. If there is no Predecessor, the BCS is derived entirely from other systems with similar components.

The HCM's primary tool is the use of comparability analysis. The comparability analysis is performed by means of a BCS as required by MIL-STD-1388-1A. The BCS is developed to resemble the Proposed System but it is not a fully integrated design. The BCS components perform functions required of the Proposed System and are similar in design to the Proposed System. The systems and subsystems used in the BCS are found in Army DOD, NATO, or civilian inventories and they must have mature, empirical field data available to be included in the BCS. This maturity of data used for the BCS and the Proposed System forms a crucial distinction between the two systems.

The Proposed System includes conceptual as well as existing features of the desired hardware, software and man-machine interface design. It may incorporate technological advances likely to exist before the system's projected IOC date. The data associated with the components of the Proposed System comes from less empirical sources such as laboratory tests or engineering estimates. The number of Proposed System alternatives depends on the number of technological designs being considered, or by the number of contractor design solutions proposed to meet the preliminary statement of mission need or system requirements by the Army.

The third objective of Systems Analysis is to quantify the reliability and maintainability (R&M) parameters for each of the respective system configurations. After the Predecessor System, BCS and Proposed System(s) have been defined, a determination of design differences can be accomplished by the HARDMAN analyst. The result of this determination, as termed by the methodology, is the Design Difference Index (DDI). This index can be used to compute BCS data to fill gaps in the

R&M parameters for the Proposed System(s). One set of DDIs is created for each proposed system comparison. Extrapolating R&M values from the BCS based on the DDI generates an estimate of the workload requirement for the Proposed System(s).

The fourth major objective of System Analysis is to specify the tasks which the operators and maintainers of the BCS Proposed System(s) will perform. Using inputs generated by previous substeps, the tasks identification step is conducted to identify the task (both equipment or non-equipment based) for each system.

The second step of HCM is Manpower Requirements Analysis. This step determines the Military Occupational Speciality (MOS) and grade, workload, and manpower requirements determination. Manpower Analysis incorporates the Manpower Requirements Criteria (MARC) process and AR 570-2 to determine manpower requirements based upon historical information, the Enlisted Personnel Management System (EPMS) and workload analysis. The initial MOS/Grade Determination is based on the selection of the candidate MOS predicated upon the equipment list and task lists from Step 1. The initial identifications are made primarily by comparing each system's generic tasks and equipment requirements with those already in existence in the Army inventory. These MOS requirements are adjusted in the training task comparability analysis conducted in Step 3 and the workload task analysis conducted in Step 2. The standards of grade authorization found in AR 611-201 (Army Personnel Selection and Classification: Enlisted Career Management Fields and Military Occupational Specialties) are applied to manpower requirements and adjustments are made. Manpower requirements are recalculated to obtain the final manpower results, which consist of the qualitative (MOS/skill level/grade) and quantitative (numbers of positions) manpower requirements for each system alternative-Predecessor, BCS and Proposed. These requirements are determined for each MOS in one system alternative, and simply aggregated giving total manpower for the system. Manpower requirements for the emerging system gives a basis for calculating the demand on Army personnel and training resources.

Step 3 of HCM is the Training Resource Requirements Analysis (TRRA) which includes the tasks comparability analysis, course requirements analysis and training cost and resource determination. There is a significant interaction between this step of HCM and the System Analysis, Manpower Requirements Analysis and the Personnel Requirements Analysis Steps (step 4). The focus of TRRA is the generation of estimates for training

products for the replacement training to support the new system at full deployment. Training associated with the proposed system's operational test and evaluation, transition and initial materiel fielding is not estimated. The development and acquisition costs of training devices, equipment, media and other training products are not estimated.

The Training Analysis step of the HCM can be performed at a general or detailed level. In a general TRRA, only the Course Requirements Analysis and Training Cost and Resource Determination are included. However, in a detailed TRRA, a Task Comparability Analysis is also conducted. The general TRRA is designed to provide initial estimates of training resources and costs early in the system acquisition process. However, the broad scope of the general TRRA makes it less appropriate for detailed tradeoffs of instructional methods and media. In contrast, the detailed TRRA is designed to be applied later in the acquisition process. At that time, detailed tradeoffs of tasks, training settings, and instructional methods/ media can be conducted.

The five major objectives of the TRRA are to provide: (1) decision-makers with estimates of institutional training resource requirements and costs for early design tradeoffs; (2) training resource planners with early estimates of the resource requirements and cost of training courses; (3) program and training managers with input to new weapon system training documents and processes; (4) training developers with a list of suitable existing training; and, (5) personnel and force structure analysts with task/skill data and student characteristics. During initial HCM application, four parameters are usually chosen to represent Training Resource Requirements: (1) Training Man-Days--the length of time needed to train students in a course; (2) Instructors--the number of trainers needed to conduct Courses of Instruction (COI); (3) Course Costs--the amount of money required to train graduates of COIs; and, (4) other training resources--a list of candidate training devices used in training. As the developmental system becomes more detailed, additional analysis can be performed to increase the accuracy of the HCM study.

The Personnel Requirements Analysis (step 4) has a single objective of estimating the personnel pipeline requirements for a new system. This step takes into consideration the quantity and the quality (skill level) of available individuals needed to support the proposed weapon system(s). HCM uses the promotion and attrition rates from the Defense Manpower Documentation Center (DMDC) and the trainees, transients holdees, or student (TTHS) rates from MILPERCEN to determine personnel pipeline requirements by MOS and grade. The Personnel Requirements Analysis provides the annual recruits required for the Proposed System(s) based upon the "steady

"state" training load after the completion of the materiel fielding plan and achievement of IOC for the system. It also provides total requirements by MOS and pay grade and the required number of recruits (annually) to support these requirements.

The Impact Analysis Step (step 5) provides for a wide range of impact analyses based on demands that a new system will make upon the MPT resource pool. The Impact Analysis concentrates on supply versus demand for various parameters. If the Army supply cannot satisfy the Proposed System demands, then tradeoffs should be investigated to try to reduce the "high driver" demand. The Impact Analysis also backtracks to the source to analyze the parameters of the "high drivers" utilizing the audit trail that the HCM provides. The three main objectives of Impact Analysis are to: identify the MPT "high drivers"; (2) identify the source; (3) analyze the parameters of the "high drivers"; and, (3) identify areas for tradeoff analyses.

The final step of HCM is Tradeoff Analysis (step 6). This step is designed to identify the alternatives that reduce or alleviate MPT high drivers; assess the impact of the alternatives on the MPT requirements; and assess the MPT impacts of additional system changes that occur throughout the system acquisition process. Tradeoff analysis is the objective for performing all the other steps. After a HCM application determines MPT requirements, then changes are tested to investigate the impact on MPT. These changes are not necessarily limited to system hardware. Aspects of the total system, including deployment, manning, operational scenario, training, recruiting and other factors are also considered. Tradeoff Analysis consists of two activities. First, the changes to be made are identified. Second, the HCM analyst performs a reiteration of any or all of the previous five steps and determines the impact that the changes have on the MPT. The Tradeoff Analysis step ensures that the decision maker is given not only the cost but impact that alternatives have on the MPT of a Proposed System.

The HCM is layed out in six progressive steps with related substeps. However, the flow does not dictate a strict linear time table. Much of the analysis in an application of HCM can be accomplished independent and/ or simultaneous to prior substeps. For example, the output from a substep of the Manpower Analysis step can be used as input or to update a substep in the Systems Analysis or vice-versa.

The general flow of data and relationships between the substeps are discussed in detail in the HCM documentation.

E. BACKGROUND.

The Army is becoming increasingly concerned with the cost and availability of the people required to operate and maintain the systems in the Army's inventory. The decisions made that effect the equipment have not until recently, considered the parameters of MPT. The manpower ceiling, cost to train soldiers, and other factors make it necessary to consider MPT in the life cycle phases prior to production and deployment. Also, approximately 70 percent of the system's life-cycle costs are fixed by decisions made prior to Milestone I.

The search by ARI in 1980 for an analysis to meet this criteria turned up the Navy HCM as the near term solution to early MPT estimation. The present HCM was developed by DRC and has the contract for the Army HCM analyses presently being conducted.

### **SECTION III. TECHNICAL EVALUATION.**

#### **A. APPLICABILITY TO MIL-STD-1388-1A.**

It is the intent of MIL-STD-1388-1A that all the tasks listed below be initiated in the concept phase of the life cycle (with the exception of task 401) with successive iterations and updates through the demonstration/ validation and full scale development phases. The HCM efforts in the concept phase will be performed with limited and/or speculative data. The results of any analysis in the concept phase should be viewed with cognizance of these limitations.

Table III-1 is a quick reference as to the extent that HCM can be applied to the tasks of MIL-STD-1388-1A. Note that Table III-1 shows some tasks as being applicable in all phases. As discussed earlier however, HCM is most beneficial in pre-concept and concept phases.

##### **Task 201. Use Study.**

Subtask 201.2.1--HCM documents quantitative data which is considered in developing support alternatives and conducting support analysis. HCM, in the System Analysis Step, documents detailed mission requirements such as mission duration, mission frequency, and number of hours, cycles, firings, flight hours, etc.

##### **Task 203. Comparative Analysis.**

Subtask 203.2.2--HCM develops the BCS through the mission, functions and functional requirements for a new system design identified in the initial O&O Plan. HCM analyses takes these functional requirements and identifies potential BCS candidate equipment in the existing Army, DOD, NATO, and commercial inventories. The BCS equipment list is compared with the design (hardware, software, and man-machine interface) of the proposed system alternatives. Similarity is judged by the best overall combination of the following factors: weight, volume, arrangement of component parts, type and sophistication of technology incorporated, and environment.

Subtask 203.2.3--HCM takes the BCS and Proposed System equipment identified in Subtask 203.2.2 and collects all the mature data available on each. The data collected includes

equipment usage rates, frequency of failure, frequency of maintenance actions, task times, MOS/skill level performing tasks, task descriptions for operation and maintenance tasks, number of personnel performing tasks, etc. Proposed system alternatives also include data from tests or engineering estimates from incorporated technological advances that were identified by the materiel developer or materiel contractors. Training costs, however, are the only O&S costs considered by HCM.

Subtask 203.2.5--HCM takes the MPT resources requirements estimated and conducts an Impact Analysis, comparing the MPT requirements of the BCS to the MPT requirements of the Proposed System(s). The Impact Analysis identifies the supportability "high drivers" a Proposed System would place on the present and future supply of MPT resources. It also retraces the analyses to identify the source (i.e., component) of the "high drivers" and analyses the parameters associated with the MPT. Training costs are calculated and can be considered a prime operation and supportability cost driver.

Subtask 203.2.6--HCM considers the technological opportunity incorporated in a proposed system when calculating the supportability, cost and readiness drivers. HCM relies on data from engineering estimates or laboratory tests for technological advances in which there are no comparable systems identified.

Subtask 203.2.8--HCM compares the design differences between the BCS equipment list and the Proposed System(s) equipment list. The result of this comparison gives the DDI. This index can be used to compute BCS data to fill gaps in the proposed system R&M and performance data. The design differences will form the rationale for perturbations of R&M values converting from BCS to Proposed System data.

#### Task 204. Technological Opportunities.

Subtask 204.2.1(b)--The Proposed System, as defined in HCM, is the best estimate of a new system design using advanced technology to fulfill all mission and functional requirements. Each Proposed System may either be an actual design obtained directly from a contractor or a conceptual design developed by the HCM analyst. In either case the Proposed System(s) may incorporate technological advances likely to exist before the systems projected IOC date. HCM estimates the impact that these improvements in technology have on MPT.

**Task 205. Supportability and Supportability Related Design Factors.**

Subtask 205.2.1--HCM is designed to provide timely information on the MPT resource requirements of emerging materiel system. This information is used for decisions on the research, development and acquisition issues affecting emerging systems and the planning of effective supportability of these systems in MPT and other logistics areas. HCM output reports include quantified manpower requirements by MOS and skill level, quantified sustainment requirements (personnel), projected training increases by MOS, projected annual training cost and initial LSA data. These reports are generated for each proposed system alternative and can identify any excessive MPT requirements associated with a particular MOS/Additional Skill Identifier (ASI). HCM does not make a distinction between peacetime and wartime conditions unless specified in the analysis.

Subtask 205.2.3--HCM estimates R&M parameters for each proposed system design. This data is collected from technical publications, test results and Army maintenance policies on the BCS and is adjusted, as required by, using the DDIs established by the HCM analysis. Functional and performance requirements for the proposed system(s) are also refined by the HCM analysis. These requirements, along with the R&M parameter estimates, provide the government with contract requirements to be included into the LSAR "A" record.

Subtask 205.2.5--HCM provides an audit trail giving it the capability to update all R&M parameters, and MPT resource requirements, as the proposed system/equipment becomes better defined.

**Task 301. Functional Requirements Identification.**

Subtask 301.2.1--The HCM functional requirements analysis step determines the functions that a system is required to perform on the battlefield. For HCM, functions are defined as actions that a system performs to accomplish its mission. These functions can be performed by the system as a whole or by specific component elements for lower level functions. HCM cannot calculate both peacetime and wartime requirements without performing separate iterations of the analysis.

Subtask 301.2.2--HCM assigns functional requirements to each function identified in previous HCM steps. For each system function, the analyst examines the systems operational environment and the performance requirements specified in the requirements documents, such as the ROC and JMSNS, and determines the functional requirements used to identify equipment components, including advanced technology, utilized in the Proposed System design(s) developed by the HCM. However, HCM considers only MPT when identifying the functional requirements which are supportability drivers.

Subtask 301.2.4.3--Functional requirements are used to identify generic operator and maintainer tasks for BCS and Proposed System(s) components. The generic tasks are abstract enough to be used for both manpower and training analysis. This flexibility establishes the audit trail from both manpower and training analyses back to equipment, functional and mission requirements of the system giving HCM the capability to track MPT "high drivers" back to these requirements. This generic task data can be used for the tasks analysis documented in the LSAR through demonstration and validation phase or until more mature data is available.

Subtask 301.2.6--HCM can be used to update functional requirements and generic operator and maintainer tasks at the system/subsystem level. This data can be utilized until more mature data can be obtained from the failure modes, effects and criticality analysis (FMECA) and Reliability Centered Maintenance (RCM) analysis or from Developmental Test (DT)/Operational Testing (OT).

#### Task 302. Support System Alternatives.

Subtask 302.2.2--HCM documents MPT requirements for each system concept alternative and the costs associated with each. HCM addresses the support concepts for each alternative down to the level required for the analysis to be performed. The Impact Analysis Step serves two purposes. The first purpose is to analyze the MPT requirements/demands of each Proposed System identified in previous steps and determine "high drivers" for each parameter of MPT. The second is to determine the availability of present and projected MPT resources allowing for supply and demand comparisons to establish whether the Army has sufficient MPT resources available to support the Proposed System's demands.

Subtask 302.2.4--HCM conducts tradeoffs using several parameters. As the tradeoffs are analyzed, the new support requirements are calculated. These requirements are then compared against original MPT projections providing the analyst with MPT savings or increased costs produced by a particular tradeoff. If computed as MPT savings, the information could be used to update viable support plans. HCM considers only MPT savings when developing viable support concepts.

Subtask 302.2.5--HCM compares the MPT "high drivers" to the resources available in the Army and identifies any risks associated with each. The Tradeoff Analysis step considers various changes to the system and the results these changes have on MPT requirements. These changes could include system configuration, maintenance concept, operational and organizational concept, training concept, and force structure. The new MPT requirements are calculated and the risks are identified for each support concept.

#### Task 303. Evaluation of Alternatives and Tradeoff Analysis.

Subtask 303.2.5--HCM determines manpower requirements from estimated workload calculations. Total manpower requirements are estimated for the predicted total Army fielding of the Proposed System for each MOS identified. The results are aggregated and displayed in five types of manpower requirement reports: (1) Operator/Crew; (2) Organization; (3) Direct Support Maintenance; (4) Force Structure Summary; and, (5) Total Requirements. Once the total manpower requirements are estimated, HCM analyzes the pipeline rates for each MOS identified. Promotion and attrition rates are used along with consideration of THS rates to establish the normalized (average) personnel flow rate for each MOS career path. HCM adjusts the stated manpower requirements by computing the number of additional personnel which must be carried in previous paygrades to support the required level at a higher paygrade. After the initial evaluations of MPT have been calculated, HCM takes alternative system/equipment designs and evaluates the changes these alternatives produce.

Subtask 303.2.6--The tradeoff analysis step of HCM provides a set of procedures for systematically iterating the methodology to consider various changes to the system and the results these changes have on the system's MPT requirements. HCM considers changes in system hardware, system's deployment, manning, operational scenario, training, recruiting and other personnel factors.

#### Task 401. Task Analysis.

Subtask 401.2.3--HCM can identify new or restructured personnel skills or training devices necessary to perform each task identified for the proposed system. This task is performed on systems in the DVAL phase or later.

Subtask 401.2.4--The training resource requirements analysis step of HCM identifies training requirement for a proposed system design based upon the tasks identified in the task analysis substep. This task is performed on systems in the DVAL phase or later.

TABLE III-1: HARDMAN - LSA Application Table.

<u>Task</u>	<u>Applicability By Life Cycle Phase *</u>	<u>Fulfillment of Task (%)</u>
<b>201 Use Study</b>		
201.2.1	H, C, D, F	50
<b>203 Comparative Analysis</b>		
203.2.2	H, C, D, F	100
203.2.3	H, C, D, F	75
203.2.5	H, C, D, F	75
203.2.6	H, C, D	30
203.2.8	H, C, D, F	75
<b>204 Technological Opportunities</b>		
204.2.1 (b)	H, C, D	75
<b>205 Supportability and Supportability Related Design Factors</b>		
205.2.1	C, D	70
205.2.3	C, D, F	30
205.2.5	D	50
<b>301 Functional Requirements Identification</b>		
301.2.1	C, D	80
301.2.2	H, C, D	75
301.2.4.3	C, D, F	50
301.2.6	H, C	50
<b>302 Support System Alternatives</b>		
302.2.2	H, C, D	75
302.2.4	H, C, D	50
302.2.5	H, C, D	25
<b>303 Evaluation of Alternatives and Tradeoff Analysis</b>		
303.2.5	H, C, D	100
303.2.6	H, C, D	75
<b>401 Task Analysis</b>		
401.2.3	D, F	25
401.2.4	D, F	25

\* H - Preconcept, C - Concept, D - Demonstration/Validation  
F - Full Scale Development, P - Production/Deployment.

**B. CALCULATIONS/EQUATIONS.**

The equations and calculations given in the methodology are not very complex, with a limited number of equations used by HCM. The principal equations for manpower are outlined in Appendix C. These calculations depend heavily on the amount of data available, as does the methodology. The equations in HCM are found to be in accordance with all regulations governing MPT.

**C. DOCUMENTATION.**

The HCM is a structured approach to determining the MPT requirements of a developmental system in the early phases of the acquisition life cycle. This approach is outlined in specific steps and substeps in the HCM guide. The documentation provides detailed procedures, algorithms, equations and sample calculations required to conduct the analysis. There are flow diagrams illustrating the data flow and interaction between the substeps. The guide is designed to serve the qualified analysts performing the analytical procedures of the methodology.

The first edition of the Army HCM Guide, Apr 85, was compiled jointly under the direction of ARI and SSC-NCR. The guide consists of five volumes. Volume I, the Manager's Guide provides the introduction/background, methodology overview, key output and decision information, and key activities for analysis management. The analyst's volumes (II-IV) provide descriptions of the 6 major steps along with the 44 substeps: Volume II - System Analysis (Step 1); Volume III - Manpower, Training and Personnel Requirements Analysis (Steps 2, 3, 4); Volume IV - Impact and Tradeoff Analysis (Steps 5, 6). Volume V provides all appendices.

The first edition of the HCM Guide is available from the Defense Technical Information Center (DTIC), Cameron Station, Alexandria, VA 22304-6145. The document numbers are:

Volume I	-	ADA 156-787
Volume II	-	ADA 156-788
Volume III	-	ADA 156-789
Volume IV	-	ADA 156-790
Volume V	-	ADA 156-791

**D. INPUT REQUIREMENTS.**

The HCM is very data intensive. The accuracy of HCM results is determined mainly by the quantity and quality of data input. A list of selected input data requirements is found in Appendix A.

The data requirements for HCM can be classified in six generic categories: (1) function requirements; (2) equipment; (3) manpower; (4) tasks; (5) training; and, (6) personnel. The functional requirements and equipment data are used in the System Analysis Step (Step 1). The manpower and task category information are used in the Manpower Requirements Analysis Step (Step 2). The task data is also used in the Training Resource Requirements Analysis Step (Step 3), along with the training data. The personnel data is used in Step 4, the Personnel Requirements Analysis Step.

The data can come from several sources. The major data sources available are listed in Appendix B.

#### E. OUTPUT PRODUCTS.

The outputs produced by any or all substeps of the HCM can be considered an output product. However, HCM produces relatively few standard output reports. These few reports provide the final MPT requirements of the emerging weapon system and the impact of these requirements on available MPT resources.

The manpower reports provide the number of individuals required to perform direct operation and maintenance of the system. HCM produces five separate manpower requirement reports: (1) Operator/Crew; (2) Unit Maintenance; (3) Intermediate Maintenance Forward; (4) Force Structure Summary; and, (5) Total Requirements. Reports can be produced for intermediate rear or depot if the analysis warrants their production. The manpower requirements are listed by MOS for the Predecessor, BCS and all Proposed System Alternatives. Each report is calculated using a single system density.

HCM provides three personnel requirement output reports. The personnel requirement equals the direct manpower required by the system under evaluation plus the personnel pool needed to maintain that manpower. The three reports are: (1) the total requirements; (2) structure by paygrade; and, (3) annual recruits. These personnel reports are listed by MOS for the Predecessor, BCS and all Proposed System Alternatives.

The Training Resource Requirements Analysis Step (Step 3) develops three output reports. The reports are: (1) Man-days of training; (2) instructor requirements; and, (3) cost to train. These reports reflect annual requirements and are listed by MOS for the Predecessor, BCS and all Proposed System Alternatives.

HCM also provides impact analysis reports supplying the ranked total manpower requirements and the availability ratio of each MOS in the Army. These reports are used to identify "high driver" MOS requirements for all Proposed System Alternatives.

F. STRENGTHS AND LIMITATIONS.

The main strength of HCM is the estimate of MPT requirements early in the Life Cycle. Identifying "high driver" of MPT in pre-concept and concept phases can eliminate more costly design changes in later life cycle phases. HCM also executes design tradeoffs between human resources and equipment, providing supportability considerations early when the majority of decisions effecting Life Cycle Costs (LCC) are being made. It can also be used by the Combat Developer to update the System Requirements Documents.

Another strength of HCM is that it is approved by Deputy Chief of Staff for Personnel (DCSPER) as a technique to satisfy MANPRINT MPT requirements. HCM and Early Comparability Analysis (ECA) are the only two methods presently approved by DCSPER. Other methods must be approved by DCSPER before they can be used.

The input requirements of HCM is a major limitation. As mentioned, HCM is data intensive. The quantity and quality of the data, determines to a great degree the accuracy of the results. The extensive data collection effort also lengthens the time to complete an analysis.

HCM is a relatively new methodology which was adapted by ARI for Army use. At the present, there is a limited number of Army personnel experienced in the application and interpretation of HCM. Until the Army can become proficient in HCM applications, we will have to rely on the contractor for accurate results of present HCM applications and the performance of necessary tradeoff considerations.

Another limitation is the number of Subject Matter Expert (SME) analysts needed to conduct a HCM study. The analysis requires an average of eight people with varying degree of skill; some requiring military experience. The personnel required, in addition to the length of time to complete an analysis, may make an HCM analysis to costly and time consuming for a small system. However, for major systems, the potential savings in the MPT area can be many times the cost of the HCM analysis.

G. CONCLUSIONS/RECOMMENDATIONS.

The HCM will satisfy the MIL-STD-1388-1A tasks stated in paragraph A, Section III. MRSA recommends the use of HCM in fulfilling the requirements of these tasks in the pre-concept and concept phases. In the later phases HCM can be used for update of MPT information but the cost savings are not as great.

At present, HCM does have limitations (Section III, paragraph F). However, the addition of the MANPRINT Data Base to consolidate HCM inputs and the efforts by SSC-NCR to develop a method for quality control check of HCM inputs, will greatly reduce the excessive data collection. The MANPRINT Data Base will also store HCM analyses and results for comparison to actual MPT requirements after the system is deployed. This data can be used to validate MPT predictions made by the HCM and identify the need for improvements to the HCM.

Appendix A  
PRIMARY INPUT PARAMETERS

Weapon System Information:

Mission Scenario (Narrative)  
Annual Operating Requirements (Usage)  
Total Number of Systems Fielded  
Operational Availability (Ao)  
Mean Time Between Failure (MTBF)  
Mean Time to Repair (MTTR)  
Mean Time Between Maintenance Action (MTBMA)  
Maintenance Ratio  
Task Codes (Maintenance Action)  
Task Times  
Maintenance Level  
Task Frequency  
Number of Personnel to Perform Task

Training Information:

Course Number  
Course Title  
Course Frequency  
Annual Training Course Cost  
Course Attrition Rate  
Training Cost Per Graduate  
Annual Instructor Requirements  
Course Length  
Optimum Class Size  
Aptitude Area and Score  
Instructor Contact Hours  
Training Location  
Training Device Quantity  
Training Device Acquisition Cost  
Training Equipment O&S Cost  
Training Facilities  
Training Facilities Cost

Personnel:

MOS/ASI  
Attrition Rate  
Promotion Rate  
Transient, Trainee, Holdee, Student Status Rate (TTHS)  
Course Title  
Course Number  
Total MOS Operating Strengths and Authorizations.

Appendix B  
DATA SOURCES

Manpower

AR 570-2      Manpower and Equipment Control Organization and Equipment Requirements Table  
AR 611-201     Army Personnel Selection and Classification: Enlisted Career Management Fields and Military Occupational Specialties

Training

TRADOC Pam 351-4    Job and Task Analysis Handbook  
TRADOC Pam 350-30    Interservices Procedures for Instructional System Development

Directorate of Training and Doctrine (DOTD) at proponent school  
Army Training Requirements and Resource System (ATTRS)  
ATRM-159 MOS Course Cost Reports  
DA Pam 570-558 Staffing Guide for U.S. Army Service Schools

Personnel

Defense Manpower Data Center  
Chief of Personnel Operations (CPOO) 45 Report

End Item

Logistic Support Analysis (LSA/LSAR) MIL-STD-1388-1A  
Sample Data Collection  
Manpower Authorization Requirements Criteria  
Operational and Organization Plan (O&O)  
Requirement Operational Capability (ROC)  
Justification for Major System New Start (JMSNS)

## Appendix C

### EQUATIONS

#### Manpower

General: Reliability x Maintainability = Maintenance Ratio

Specific:

$$\frac{1}{M[M]BMA} \times MTTR \times K = \frac{\text{MAN-HOURS}}{\text{ONE METRIC}}$$

Where:  $M[M]BMA$  = Mean [Metric] Between the Maintenance Action being analyzed, metric expressed in time (MTBM), rounds (MRBMA), etc.

MTTR = Mean Time to Repair

K = Number people required for the action.

The maintenance ratio is calculated and summed for each maintenance echelon. Direct maintainer workload at one maintenance echelon is calculated by:

$$\frac{\text{USE}}{\text{Period}} \times \text{Maintenance Ratio*} = \text{Workload}$$

(One Echelon)

Where: USE--Quantitive requirements for operational system activity/usage under scenario conditions; expressed in metrics (MIL-STD-721C)

Period--Duration of the scenario requirement (day, week, month, year)

Maintenance Ratio--A measure of the total maintenance manpower burden required to maintain a system. It is expressed as the cumulative number of manhours of maintenance expended in direct labor during a given period of time divided by the cumulative number of end items operating during the same time (DA PAM 700-127).

\* Indirect maintenance man-hours can be calculated using the ratios supplied by AR 570-2.

Manpower is calculated using:

General:

$$\frac{\text{Workload} \times \text{Force Structure}}{\text{Work Capacity}} = \text{MANPOWER}$$

Where: Workload--The amount of work, stated in predetermined work units, that organizations or individuals perform or are responsible for performing (AR 310-25)

Force Structure--The total number of systems the Army is planning to field and the anticipated distribution of the systems to various elements of the Army.

Work Capacity--The amount of workload a position can be assigned (AR 570-2)

Manpower--The total demand, expressed in terms of the number of individuals, associated with a system (MIL-STD-1388-1A). Includes the number of individuals in each MOS/ASI, skill level, and paygrade required to operate and maintain a system.

Specific:

$$\frac{\frac{\text{Man-Hours (Direct and Indirect)}}{\text{System}} \times \# \text{ of Systems}}{\frac{\text{Man-Hours Available}}{\text{MOS Position}}} = \# \text{ of Positions}$$

This equation is applied to each MOSC identified.

## Appendix D

### ACRONYMS

#### A

AMC            Army Materiel Command  
ARI            Army Research Institute  
ASI            Additional Skill Identifier  
ATRM          Army TRADOC Resource Management  
ATTRS         Army Training Requirements and Resources System

#### B

BCS            Baseline Comparison System  
BDP            Battlefield Development Plan

#### C

CMF            Career Management Field  
COI            Course of Instruction  
COPO          Chief of Personnel Operations

#### D

DCSPER        Deputy Chief of Staff for Personnel  
DDI            Design Difference Index  
DMDC          Defense Manpower Data Center  
DOD            Department of Defense  
DOTD          Directorate of Training and Doctrine  
DRC            Dynamic Research Corporation  
DT/OT         Developmental Testing/Operational Testing  
DTIC          Defense Technical Information Center  
DVAL         Demonstration/Validation

#### E

ECA            Early Comparability Analysis  
EMPS          Enlisted Personnel Management System

#### F

FEA            Front End Analysis  
FMECA        Failure Modes Effects and Criticality Analysis

#### H

HARDMAN      Hardware vs Manpower  
HCM            Hardman Comparability Methodology  
HMPT          Human Factors, Manpower, Personnel and Training

I

IOC      Initial Operational Capability

J

JMSNS    Justification for Major Systems New Start

L

LCC      Life Cycle Costs  
LSA      Logistic Support Analysis  
LSAR     Logistic Support Analysis Record

M

MAA      Mission Area Analysis  
MARC     Manpower Requirements Criteria  
MILPERCEN Military Personnel Center  
MIL-STD   Military Standard  
MOS      Military Occupational Speciality  
MOSB     MOS Training Cost Handbook  
MOSC     Military Occupational Speciality Code  
MPT      Manpower, Personnel and Training  
MR       Maintenance Ratio  
MRSA     Materiel Readiness Support Activity  
MTBF     Mean Time Between Failure  
MTBMA    Mean Time Between Maintenance Action  
MTTR     Mean Time to Repair

N

NATO     North Atlantic Treaty Organization  
NBC      Nuclear, Bacteriological Chemical

O

O&O      Organizational and Operational  
OT       Operational Testing

P

POI      Program of Instruction

R

R&M      Reliability and Maintainability  
Reg      Regulation

S

SDC      Sample Data Collection  
SME      Subject Matter Experts  
SSC-NCR Soldier Support Center - National Capital Region

T

TAMMS	The Army Maintenance Management System
TD	Training Developer
TOE	Table of Organization and Equipment
TRA	Technical Review and Analysis
TRADOC	Training and Doctrine Command
TRAMEA	TRADOC Management Engineering Activity
TRRA	Training Resource Requirements Analysis
TTHS	Transients, Trainees, Holdees and Students

Appendix E

DISTRIBUTION LIST

DISTRIBUTION:

COMMANDERS

AMC (AMCSM-PLP)  
AMCCOM (AMSMC-LS(R)/AMSMC-RDA-S)  
ARDC (AMSMC-LS(D))  
ARI (PERI-SM)  
AVSCOM (AMSAV-LFS/AMSAV-BB)  
BRDC (STRBE-TIS/STRBE-H)  
CECOM (AMSEL-LO/AMSEL-PL-SA/AMSEL-ME-ME/AMSEL-POD-SA)  
CRDEC (AMSMC-LSC(A))  
CSLA (SELCL-NMP-MM)  
CTA (AMXCT-SS)  
DESCOM (AMSDS-SM-I/AMSDS-X)  
EMRA (SELEM-ME-FM-I)  
INSCOM (IALOG-RG)  
LABCOM (AMSLC-OP-SL)  
LOGC (ATCL-MRI/ATCL-OOA/ATCL-OOS)  
MICOM (AMSMI-IL/AMSMI-OR-SA/AMSMI-LC-LS)  
MTL (SLCMT-DAC-EL)  
NRDC (STRNC-EM/STRNC-C)  
NVEOC (AMSEL-NV-PA/ILS)  
SSC (ATZI-NCM)  
TACOM (AMSTA-HC/AMSTA-MFS/AMSTA-HP)  
TECOM (AMSTE-EV-R)  
TROSCOM (AMSTR-LFS/AMSTR-LE/AMSTR-BT)

DIRECTORS

AMSAA (AMXSY-L)  
AMSAA-IRO (AMXSY-LIRO)  
AMSAA-LSO (AMXSY-LLSO)  
AMETA (AMXOM-QA)

COMMANDANT

ALMC (AMXMC-ACM-MA)

END

12 - 86

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